TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XVII, No. 3. MARCH, 1940. PRICE 6d.

CONTENTS.

	PAGE.
Fundamental Agricultural Research at the Present Time	41
Quality Coffee	42
Preliminary Notes on Cattle Improvement and the Possibilities for Mixed Farming in the Middle Belt and Southern Provinces of Nigeria	43
Losses to World Agriculture through Root Disease of Crops	49
New Polyploids in Cotton by the Use of Colchicine	53
Reviews	54
Miscellaneous Notes	55
A Contribution to Raw Sugar Clarification ...	56
Field Experiments with Sugar Cane ...	59
Chemical Notes	60

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, Broadway Bldgs., Westminster, S.W. 1, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

FUNDAMENTAL AGRICULTURAL RESEARCH AT THE PRESENT TIME.

At the present time, agriculture assumes prominence as the foundation of all human activities. The problem of obtaining more and more sustenance from the land without loss of fertility is being emphasized as of primary importance: it will continue to be of no less importance when the war is over. The deplorable slump in the market for primary products which has characterised agricultural economics of recent years has never been a valid argument against working towards increased efficiency of food production as this state of the agricultural industry has been induced by political policies hindering the relations between labour, capital and goods throughout the world. It is not abnormal increases in foodstuff supplies but the fluctuating purchasing power of money following the last war and the inadequate demand of certain manufacturing communities which have contributed largely to this depression.

At the outbreak of war research workers in every branch of science volunteered for all forms of National Service, but it has been laid down that, on the whole, scientists shall not be diverted from their present work except to serve in their professional capacity. It is clearly in the present Imperial interest that the work of research scientists should, wherever possible, be along the lines most likely to produce practical results; this applies particularly to those concerned with agricultural problems. There is, however, considerable danger that the exigencies of the present situation may result in a policy of concentrating the activities of the staffs of agricultural research institutions on work of limited and local importance to the detriment of work of more fundamental nature which is the accepted major occupation of such institutions. Such a policy would be, to say the least, unfortunate in so far as it would result in some abandonment of long-range research already in progress with loss of valuable material and "staleing" of data.

The pursuit of problems of short-range significance to the exclusion of problems in the relation of fundamental science to agricultural practice is a policy unsuitable to any institution in which basic research is a major activity: it should be enough that advice on such local problems be given, when required, by the research stations to the bodies best suited to undertake

such investigations, namely departments of agriculture staffed with officers trained to apply and instruct others in the application of the advances in knowledge gained in the scientific institutions.

The strict limitation of research in a major research institution to short-range problems such as methods of control of local pests, selection of higher yielding strains of some crop plants, &c. would be a short-sighted one unjustifiable on any scientific grounds: if the institution can command sufficient funds to continue research at all in these difficult times the adoption of such a limited policy cannot be justified on economic grounds either. If research is to be continued, a knowledge of the potentialities of fundamental applied research should ensure the continuance of fundamental work in no less degree than that of the relatively simple investigations, the results of which can have only local application. When close contact is maintained with members of the planting community there is little danger of the research policies of an institution becoming divorced from agricultural realities. For example, in the West Indies the duties of advising and organising the agricultural industry belong to the Departments of Agriculture; through the broad-minded attitude of these Departments and the excellent relations existing between them and the Imperial College all sections of the College are able to maintain informal but close personal contacts with a number of planters which would seem to provide a thoroughly adequate safeguard, at all times, against over-indulgence in lines of research too far removed from those of potential practical application.

As instances of the vital relation between fundamental and empirical researches some problems under investigation at the College may be adduced. The breeding of a banana combining the qualities of the Gros Michel with immunity from Panama disease must be a laborious and possibly vain search involving innumerable sterile attempts unless a simultaneous investigation of the cytology of banana varieties and of the immediate generations of the progeny of crosses is carried out. Similarly, in regard to cocoa the new methods of vegetative propagation render possible the immediate multiplication of cocoa trees resistant to diseases and pests. There seems no reason why cocoa should not be bred which will combine yield and quality with some degree of resistance to, at least, one or two of the major diseases. But before this can be done not only must the resistance be proven for each disease in the selected plants but also the factors, both genetic and physiological, upon which this resistance depends, require elucidation. In investigations connected with the storage of fruits and vegetables empirical trials of various methods of storage give rise to so many problems that research into the nature of the metabolism of the subjects of investigation becomes essential for the restriction of the expensive empirical trials to the bare minimum necessary to demonstrate the practical application of the fundamental work. In addition, investigations connected with the yield or storage of agricultural products give rise to major and urgent problems concerning assessment and analysis of quality.

There is danger, at such a time as this, that the natural desire to see quick results from an institution's investigations may be allowed to determine, to some extent, its immediate policy. The recognition of the underlying implications of any immediate problem requires specialised knowledge which the practising agriculturist can rarely be expected to possess and, though his knowledge is always of great value, his influence should not be allowed to decide the lines of attack of the investigator on such problems. The basal work underlying the more obvious and more easily understood work of "practical" research is that on which the justification and reputation of a professing research institution will depend, and the continuity of such work requires even more jealous guarding in times of stress.

Once again it is emphasized that fundamental scientific research continues to be the basis on which all advances in the art of agriculture are mostly likely to be made and that the rate of such progress will be conditioned by the pace of the suitable directed advances in the sciences cognate to agriculture.

H. R. B.

QUALITY COFFEE.

In an article dealing with the production of quality coffee which appeared in the *Mon. Bull. Coffee Ed. Kenya*, 1939, V, the author, a planter, endeavours to account for the difficulty of producing highest quality coffee in Kenya, on older plantations. (*a*) No essential mineral deficiency has been traced by the soil chemists. (*b*) None of the estates that produces the highest marks indulges in heavy manuring. (*c*) While it is probable that serious overcropping may adversely affect the liquor it is certain that small crops on healthy trees do so. The best liquoring coffee comes from the heavy croppers. (*d*) The best quality coffee is produced on the oldest wood, therefore shoots which are to carry the season's crop should be in existence as early as possible the previous year. None of the estates producing the best quality coffee seems to practice heavy pruning. (*e*) There are indications that multiple stems produce better coffee than single stem trees. From these and other observations it is concluded that the leaf/crop ratio has a very important influence on the liquoring quality of coffee and that in the case of young coffee up to about 10 years the ratio of crop to foliage is naturally correct and almost constant. After that age, however, owing to the unnatural topping of the tree at 5 feet or so, the tendency is for the foliage to increase at a far greater rate than the crop, thus throwing the tree out of balance and producing coffee of poor liquoring quality.—(*Hort. Abs.*, Vol. IX, No. 2, Abs. 622, 1939.)

PRELIMINARY NOTES ON CATTLE IMPROVEMENT AND THE POSSIBILITIES FOR MIXED FARMING IN THE MIDDLE BELT AND SOUTHERN PROVINCES OF NIGERIA.

By J. W. R. Pedder, Dip. Agr.
(*Senior Agricultural Officer, Nigeria.*)

Introductory.

For some years past the Department of Agriculture has advocated, for the Middle and South-Western Provinces of Nigeria, a system of green manuring, and has demonstrated that the fertility of the soil can be maintained by the use of a green manure crop. For various reasons the Nigerian farmer has not adopted this system to any extent, preferring to continue with his own method of shifting cultivation. Even in areas where the decline of soil fertility has already become very serious, *e.g.* Ogbomosho, green manuring has not been readily taken up, partly because the system involves greater labour and necessitates careful attention to the details of planting, weeding, and after care, and partly because the land previously had been allowed to get into such an exceedingly poor state of fertility that either a green manure crop could not be grown successfully, or one crop was not sufficient to restore reasonable fertility. In addition, except for its value in maintaining the fertility of the soil, a green manure crop had no apparent economic value.

So poor has the soil become in certain areas that some method of rejuvenation has become imperative, especially in areas in the South-Eastern Provinces where the population per square mile is high.

In many of these areas small shorthorn cattle are kept, but for many generations these cattle have been of no economic value to their owners and certainly full economic advantage has not been taken of them. The animals have been allowed to run practically wild and to fend as best they can for themselves; management is non-existent and breeding from immature stock and inbreeding is rampant. Sale of the animals for meat is not generally common ; their only value would appear to be the prestige that ownership confers and the provision of meat at ceremonial functions. These small shorthorn cattle, owing to their habitat, have acquired over countless generations a very high degree of tolerance to trypanosomiasis. They may therefore provide a good foundation for mating with larger animals which also possess a high tolerance, but which are not available in any quantity. It would seem obvious that wherever they can be kept, one valuable method of utilising them, as dung makers for the farm, must be demonstrated to the owners. In course of time this may lead to better stock management and consequently to natural improvement of the cattle provided disease is kept under control.

A farming system involving some type of mixed farming therefore seemed desirable for these areas. Two main lines of policy bearing a close relationship to each other were necessary :— (*a*) mixed farming systems, and (*b*) improvement of cattle. The second problem was as important as the first because these little cattle of the Southern Provinces seemed too small to be used for ploughing.

Preliminary Enquiries.

The investigations, commenced in 1932, were begun at Ilorin in the Middle Belt of Nigeria, where conditions are intermediate between the North and the South in respect of tsetse and trypanosomiasis. The system then envisaged was a modified form of the mixed farming that was beginning to be successfully demonstrated and taken up by farmers in the Northern Emirates.

At a very early date the difficulty of the problem became apparent. It was found that even in Ilorin, the mortality rate among Zebu cattle was very high, due mainly to trypanosomiasis and, after further unsuccessful attempts to use these Zebu animals from Northern Nigeria, it appeared that their use for general farm work in this area was not going to prove economically sound.

On the other hand an attempt was made to utilise the considerable indigenous cattle population in Ilorin Province and surrounding areas for our purposes. This attempt was attended with more success. Obviously local cattle have some tolerance to trypanosomiasis, but this tolerance was not sufficiently high to prevent fairly frequent breakdowns when they were worked. These animals also were therefore not entirely satisfactory for general use, but did indicate a possible solution to the cattle problem.

The next enquiry was to ascertain what line of breeding had been followed with the local herds whereby the animals exhibited a sufficient tolerance to protozoal infection to live in the area. The result of these enquiries among cattle owners indicated that forty or fifty years previously the cattle of this area had little or no hump, and only in recent years, with the Fulani penetration, had the animals become larger and more humped, due to a considerable admixture of Zebu blood through the more constant use of sires of that breed. Thus, in some areas, which are comparatively free from tsetse, the cattle now more nearly approach the White Fulani Zebu in appearance and conformation, whereas in others where contact with possible Zebu sires is not so common, or the incidence of tsetse and consequent trypanosomiasis is higher, the animals do not exhibit Zebu characteristics to anything like the same extent.

The small shorthorn cattle of the Southern Provinces were of course known to exhibit considerable tolerance to trypanosome infection but it was not considered at that time that they could be of any economic value on account of their size and conformation.

Introduction of Cattle from Gold Coast.

In 1934, information was obtained from the Gold Coast on the cattle of that country. It was said that these animals were larger than the small shorthorn cattle of Nigeria, were capable of draught work and possessed a high tolerance to trypanosome infection. These beasts, now known as the West African Shorthorn, are so named and described in "Cattle of the Gold Coast" (Stewart) (1).

In 1935 the Ilorin Native Administration purchased some of these cattle in the Gold Coast and brought them to Ilorin in order to try and assist in producing an animal which would be suitable for mixed farming. It was unfortunate that there did not seem to be any bovines in Nigeria, possessed of the necessary high tolerance to trypanosome infection which were large enough to be of real economic value to the husbandman. Admittedly there were individual animals which did partly meet these requirements but the numbers available were very limited and the degree of admixture of Zebu blood varied considerably.

The original herd of Gold Coast cattle consisted of 34 cows and heifers and four bulls. This herd was trekked across the country from the area around which it was purchased, in the Northern Territories of the Gold Coast, to Ilorin in Nigeria, a distance of between 700 and 800 miles. The journey occupied some six weeks; only 3 animals were lost on the way. The trek was undertaken during the dry season when grazing was of the scantiest and water difficult to obtain. In spite of their long trek the beasts arrived in Ilorin in very fair condition, thus clearly demonstrating their hardiness. Soon after their arrival, however, an outbreak of contagious bovine pleuro-pneumonia nearly wiped out the herd. When this outbreak was under control towards the end of the year the herd was reduced to 12 cows and heifers, 6 calves and 4 bulls. With this number the preliminary investigations continued during 1936 under the auspices of the Ilorin Native Administration.

Only two of the Gold Coast bulls were adults; these were broken to draught and put to farm work, ploughing, cultivating and carting work which they were readily capable of performing without either loss of condition or apparent breakdown to trypanosomiasis. So satisfactory did they prove that the original intention 'to try to find the best cross between them and the Zebu cattle, and then try to fix it as a permanent breed,' (2) was not proceeded with.

The French authorities about this period reported the success which they had obtained with the Fouta Cattle (variously called Fouta N' Dama or Malinke) of French Guinea, in schemes for the improvement of local cattle in French Equatorial Africa. The Gold Coast Department of Animal Health also had had some experience of this breed and fully confirmed the opinion of the French authorities.

From other sources it was affirmed that the cattle of the Gambia possessed a high tolerance to trypanosome infection in that country and measurements which were obtained indicated that they were taller than those which had come to Nigeria from the Gold Coast.

The Ilorin Stock Farm Scheme.

During 1936 it became obvious that a system of mixed farming was an economic possibility in the Middle Belt and might also be possible in some of the Southern Provinces if animals such as the Gold Coast shorthorns, possessing the necessary tolerance to environmental conditions, were used. The outstanding difficulties at the time were the lack of knowledge of the degree of tolerance to trypanosome infection which known varieties of cattle possessed, the very limited numbers of suitable animals, the need for a further extension of experimentation on mixed farming problems and the fact that the local husbandman was unaccustomed to handling cattle. To overcome the scarcity of suitable cattle and also to study the question of tolerance, the establishment of a large stock farm was proposed. This proposal was subsequently modified to a small central stock farm and several small self-contained farms (Unit farms) situated in various localities of Ilorin Province.

As a result of Sir Frank Stockdale's visit to Nigeria in 1936, a scheme was submitted embodying this latter proposal and ultimately a grant was made from Colonial Development Funds to cover the capital expenditure of the scheme, the Government of Nigeria undertaking to provide the recurrent expenditure.

The Ilorin Stock Farm scheme was launched in 1937 when the funds became available, and Government Agricultural activities in Ilorin Province became centred on the Stock and Unit Farms. As the scheme envisaged was of more than local importance and indeed affected the interests of Southern Nigeria generally, the Ilorin Native Administration handed over to Government the land and stock, both live and dead, that they possessed as "Ilorin's contribution to Agricultural Development" and ceased to finance these activities. They also assisted very materially with land for Unit farms under the new scheme.

The scheme as approved was that there should be at Ilorin a small Central Farm consisting of 100 acres of arable land, which would "work out by field experiments, the farming and animal husbandry methods to be used on the Unit Farms". This farm would carry 40 cows and 20 working bullocks. Twenty Unit Farms were to be established at various points in Ilorin Province. Each Unit Farm was to be a holding for a farmer and his assistant, ten acres in extent, to be stocked with two cows, two work beasts and a yearling of either sex. Observations were to be made of the effect that varying environments had on the

(1) *Empire Journal of Experimental Agric.* Vol. VI, No. 21, January, 1938.
(2) Annual Report Agricultural Department, Nigeria, 1935.

cattle. The methods of agriculture employed were to be those which had proved themselves economically sound by experiment on the Central Stock Farm. The Scheme also took into consideration the purchase of further cattle from Gambia, from French Guinea, additional animals from the Gold Coast and cows from local sources to make up the numbers of adult stock necessary.

The Agricultural Department of Gambia on behalf of the Nigerian Government purchased ten bulls and, unfortunately, only one cow and one heifer were obtainable from among the cattle of that country. These beasts arrived in Nigeria towards the middle of 1938. At the beginning of that year a further consignment of cattle was purchased in the Gold Coast, but unfortunately it was possible to obtain beasts only in the Coastal area, where the cattle are not of such a good stamp as those originally bought in the Northern Territories. Also in 1938 some cows and heifers were purchased in Dahomey which all showed obvious Zebu characteristics but possessed a sufficient tolerance to trypanosome infection to warrant their use as foundation cows. Finally in 1939 a purchase was made of thirty Fouta cattle in the Fouta N'Dama area of French Guinea. This herd which consisted of ten bulls, two calves and 18 cows and heifers arrived in Nigeria in February, 1939.

Unit Farms.

For the areas of the Middle Belt and Southern Provinces where the introduction of mixed farming is envisaged, Unit Farms are a necessary adjunct. The primary object of these farms is to ascertain over as wide a range of localities and environmental conditions as possible what economic use can be made of cattle in local farming practice. Once it is known that improved animals can live, then it is necessary to adapt them to agricultural conditions. These animals can live in the Middle Belt; but there are many areas in the Southern Provinces, where the small Nigerian shorthorn is found, where it still remains to be proved that a Gold Coast or Fouta can live. If improved cattle can live and can be used for draught purposes on the farm, then the possibilities for a more extensive form of mixed farming are opened up. If, on the other hand, they are not able to work, then the small shorthorn will be sufficient to supply dung for the farm, and an adaptation of mixed farming must be evolved for the crop requirements of the area.

To investigate these problems Unit Farms have been established in ten areas of Ilorin Emirate and two in Oyo Province. These farms are being conducted on more or less the same lines, *i.e.* the farmer and at least one assistant live close to the holding and the cattle, consisting of two work beasts, two cows and young stock, are housed within the farm. The arable area of the farm is ten acres, divided into acre fields. A system of cropping suitable to the locality is employed and a rotation is performed by moving one acre's crops to the next acre annually. This method of rotation has been found to be sufficiently simple for the ploughmen working these farms to follow with the minimum of supervision. The rotations and methods of cropping employed are not by any means fixed and in light of further experience may be radically changed. Each acre field is at present double cropped annually.

It has been found that the five beasts at a Unit Farm will produce ten tons of farmyard manure per annum provided the animals are stall fed over the greater part of the year. Each cattle pen has a small fenced yard attached in which grass and rations are fed. Maize and sorghum straw and other waste products of the farm are trampled down into a fit state for addition to the bedding of the pen. Where possible in the rotation a half year green fodder crop is grown on which the animals are tethered, thus manuring that area. It is hoped that by the cultivation of fodder grasses in strips through the farm and on the boundaries it will be possible to maintain the stock on home grown grass throughout the year and so dispense with the necessity for any grazing outside the area. The economics of this type of farm are still under investigation and full details are not yet available, but it is expected that when this system is fully established it will be possible for the farmer to be self-supporting and that he will have food for his cattle, himself and his dependants, and have a considerable surplus of his farm and animal produce for sale.

In addition to this type of Unit Farm where cattle can be employed for work, others are being established in forest country at Abeokuta, Agege, Benin, Umuahia and Onitsha, which are at present stocked with the small Nigerian shorthorn.

It has not yet been found possible to work these small animals and these farms, perforce, have to be cultivated by hand, and the stock is only used to turn the waste products of the farm into dung. In course of time when the improved cattle become available they will be tested out on these farms. If these latter animals can tolerate the conditions sufficiently to allow them to perform work then animal drawn implements will be used for cultivation and the area under crops enlarged; the small shorthorn will be gradually replaced with their progeny by improved sires and with pure improved beasts.

Sites of Unit Farms.

In the preliminary stages of the scheme suitable sites had to be found for Unit Farms. The Senior Entomologist of the Agricultural Department made numerous tsetse surveys in Ilorin Emirate and finally certain localities were proposed. At this stage it became apparent that it would be difficult to obtain, in the comparatively small area of Ilorin, any great variation in environmental conditions or tsetse incidence, but as stock for Unit Farms were not then available this was not a pressing problem. Approval, however, was obtained to establish some Unit Farms in the Southern Provinces.

After further intensive surveys of the tsetse population in Ilorin Emirate ten sites for Unit Farms were decided upon and the erection of the necessary farm buildings and the clearing of the land was commenced. The Senior Entomologist evolved a system whereby each farm was classed according to the tsetse incidence, on or adjacent to the farm. In all farm areas tsetse had been found.

In 1938 three Unit Farms successfully completed their first farming year, one within the boundary of the Central Stock Farm at Ilorin and the other two in districts of Ilorin Emirate. During the year seven other Unit Farms were prepared and some stock sent to them. Unfortunately, owing to lack of suitable cattle, it was not possible to supply them with work animals until the beginning of 1939. The 1938 programme on these latter seven farms was therefore to prepare the farm area as far as possible by hand, to provide food for the animals and to observe what effect the conditions had on the cows and young stock at the farm.

In addition to these Unit Farms in Ilorin Emirate one complete Unit Farm was established early in 1938 at Moor Plantation, Ibadan, and a start made in establishing further Unit Farms on the Agricultural Department's plantations at Abeokuta, Agege, Onitsha and Benin, these latter farms all being in forest or semi-forest country of the Southern Provinces of Nigeria. With the exception of the Unit Farm on Moor Plantation, stock for the farms consisted of the small shorthorn cattle of the locality. The main function of these farms, in their preliminary stages, was to study animal management and the effect of farmyard manure on the crops of the district.

At Umuahia in the South-Eastern Provinces work with cattle started towards the end of 1934 on the departmental plantation. Only three animals, a cow, an in-calf heifer and a bull, constituted the herd of small Nigerian Shorthorns at that time. The object of keeping cattle at Umuahia was to see whether a modified form of mixed farming was possible in the Eastern Provinces and also to observe the effect of farm yard manure on the local crops. By further purchases and normal increase this herd now consists of 24 animals.

Breeds of Cattle.

As mentioned already there are at the Central Stock Farm numerous types of bovine possessing a tolerance to protozoal infection sufficient to be of value for mixed farming. These are described below.

The Small Shorthorn (*Bos Brachyceros*).

This type is the indigenous bovine of the Southern Provinces of Nigeria, a type which is found in the coastal and forest areas of many of the West African countries. It is a very small animal; the cows stand about 36 inches in height from the ground to the withers and weigh approximately 350 lbs. A considerable number of them show distinct dwarf characteristics. There are at present five 'pure' small shorthorn females on the farm, four of which are adult. These cows are being used to breed to bulls of the imported types. Their progeny, when mature, are larger than their dams and appear to possess a tolerance to trypanosome infection equivalent to that of their dams. The crossbred calves are inclined to have a somewhat unthrifty appearance until they are weaned, possibly on account of the small milk supply of their dams. 'Pure' small shorthorn calves take from 70 to 80 weeks to reach 300 lbs. live weight, whereas the cross bred calves take some 58 to 60 weeks to reach this weight. With regard to work, there is only one 'pure' small shorthorn bullock which has been broken. He may be an exceptionally weighty animal for the type, weighing as he does just over 5 cwt. This bullock appears quite capable of performing all the work asked of him, so the increase in size of the small shorthorn to enable them to work will not need to be great.

With regard to the breed's tolerance to protozoal infection two animals purchased by the Veterinary Department in Shendam (Plateau Province) were taken to Vom in 1931, where tsetse is said to be non-existent. They were transferred to Ilorin in 1938 where they were exposed to any infection there was but so far have been in excellent health. Other small shorthorns have at times exhibited trypanosomes in blood smears taken from them, but without any apparent effect on their general health or condition. The cows have bred annually and have, between them, produced twelve cross bred calves, nine of which have exhibited trypanosomes in their blood smears but have never had to be treated for trypanosomiasis. There has so far been no calf mortality. Whether this tolerance has become a hereditary factor or not has still to be proven.

Gold Coast Shorthorns.

According to Stewart these cattle are a mixture of the Hamitic Longhorn, Brachyceros, with additional Zebu blood. This latter addition would not appear to have been sufficient to reduce their tolerance to trypanosome infection to any material extent, but it still has to be ascertained whether they can live wherever the small shorthorn is found.

Gold Coast shorthorns in appearance might be small specimens of European breeds of cattle. The four adult bulls in the herd at Ilorin average 769 lbs. in weight and stand an average of 45 inches in height from the ground to the withers; nine adult cows average 541 lbs. in weight and average 42 inches in height from the ground to the withers.

There have so far been two importations of this type of animal to the Central Stock Farm at Ilorin, the first in 1935 and the second in 1938. The animals of the first importation have been maintained in excellent health, and the cows have calved annually. Four bulls have proved

Fig. 1.—Fouta Longhorn Bull.

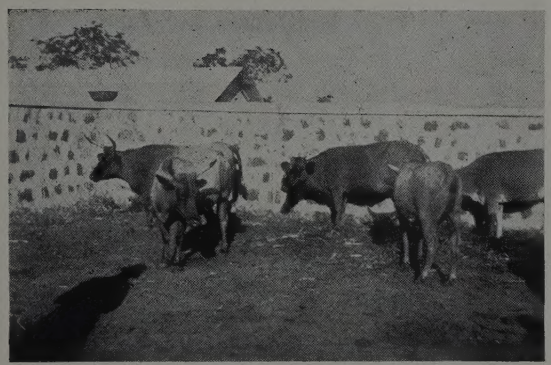

Fig. 2.—Fouta Longhorn Cows.

Fig. 3.—Nigerian Shorthorn Cows with Crossbred progeny behind.

Fig. 4.—Young Gold Coast Bull (30 months old).

Fig. 5.—Gold Coast Shorthorn Cows.

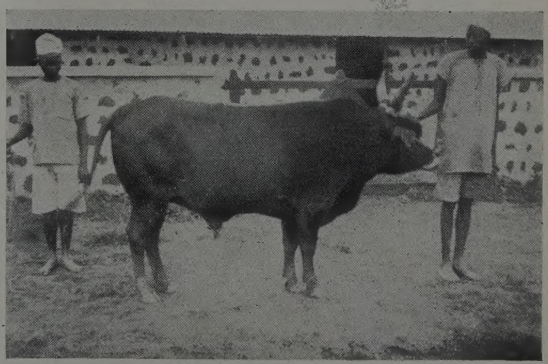

Fig. 6.—Gambia Longhorn Bull.

themselves to be excellent draught animals, working during 1938 an average of 77 hours per month throughout the year, ploughing, cultivating and carting. Trypanosomes were found in blood smears from all of these bulls, and one only recently required resting for two days to effect recovery. From ten cows, thirty-four calves have been born since 1935; 21 of them have had trypanosomes in blood smears. Two calves only have died, one from trypanosomiasis and the other from scour.

The animals of the second importation came from the Ada area of the Gold Coast and in point of size and usefulness have not proved themselves to be as satisfactory as the first importation. This is probably because the herd owners of the coastal plains are not as attentive to herd management as is the case in the more northerly areas and an inferior type of bull is more common as the herd sire.

Fouta Longhorn.

Ten bulls, 18 cows and heifers and two calves at foot of this type of bovine were purchased in French Guinea in January of 1939. It is early yet to make any statement on the value of these animals. So far at Ilorin they have been in excellent health, and they appear to have considerable tolerance to the conditions pertaining to this environment. Trypanosomes have been seen in the blood smears of six of the animals, and redwater has also been diagnosed since their arrival, without apparent effect.

The Fouta is a good stocky type of animal varying in colour from light chestnut to dark brown. They are not dissimilar in appearance to the West Highland cattle except of course that they are smaller and short haired. There is a number of polled females but polled males are scarce and are apparently never used for stud in their own country. When these cattle are in condition it is possible that they may be heavier in weight than the Gold Coast Shorthorns; but they are not as high from the ground as the latter. Nine Fouta Longhorn bulls average 42 inches from the ground to withers and eleven cows 40 inches.

The bulls have been broken to farm work, which they perform without difficulty and without any loss in condition.

Nothing can yet be said about the faculty mentioned by Stewart, that 'crossing with a N'Dama both improves the inferior breed and at the same time increases its resistance to the ordinary bovine diseases of West Africa; in the latter respect the N'Dama is unique' but it is hoped to obtain information on this point in due course, and if it proves a fact under Nigerian conditions it will be of great value.

Gambia Longhorn.

It would appear that these animals are an offshoot of the Fouta with, probably, a plentiful admixture of Zebu blood. In consequence of this admixture the Gambia seem less tolerant to tsetse conditions than the above types, so they will be less useful for herd improvement purposes. In size they are taller than the Gold Coast Shorthorn being some 47½ inches from the ground to the withers. They are, however, not as heavy as the latter. During the year that the ten bulls, a cow and a heifer have been at Ilorin, their tolerance to trypanosome infection has not appeared to be much greater than the local Sanga (Ketaku).

Sanga (*Ketaku, Kaiama and Borgu.*)

As the supply of the females of other types was insufficient for the requirements of the scheme, some 40 cows and heifers were purchased in Dahomey and the Kaiama Emirate of Ilorin Province. These animals exhibit considerably more Zebu points than the Gold Coast Shorthorn; they have small humps, which however tend to be more cervical than thoracic and the set of the horns and the slope of the hind quarters is more characteristic of the Zebu than of the shorthorn.

In this particular area this type of bovine does possess a tolerance to trypanosome infection, but this tolerance is insufficient for the type to be able to live in an area where tsetse infestation is high. These females are therefore being used as foundation cows to cross with Fouta, Gold Coast or Gambia bulls, the progeny to be graded to one or other of these more tolerant types.

Sanga males have had to be used as work beasts on the Stock Farm and on some of the Unit Farms but, as they have in many cases to be treated for trypanosome infection, they are not suitable for the average Nigerian farmer, who is unlikely to be able to obtain treatment for his animals in case of need. Even with treatment, several deaths due to trypanosomiasis have occurred among both the work beasts and the females.

Zebu (*Bos Indicus*).

Since the Stock and Unit Farm Scheme has been in operation, the only Zebu animals that have been brought on to the farm are those from the Sleeping Sickness Research Station at Gadau, and some animals from the Veterinary Department at Vom. The 11 animals received from Gadau were said to be very highly tolerant of trypanosome infection as they had been in an area of high tsetse incidence. On transfer they were trekked from Gadau to Zaria, where they remained for some six months and were then sent by train to Ilorin where they arrived at the end of October 1937 in very fair condition. In the course of a very few weeks the beasts began to lose condition although they were being fed the same rations as animals in work. By March 1939 only one animal was left. The others all either died or had to be destroyed on account of trypanosomiasis; treatment was of no avail.

Six Zebu animals from Vom arrived in August and by November one succumbed to trypanosomiasis and all but two of the others followed. Only one of the two present survivors, a yearling bull, put on weight in a normal manner and

trypanosomes were not discovered in blood smears taken from him. It is unlikely that this beast could have escaped infection, so it seems possible or even probable that he possessed a considerable individual tolerance to trypanosome infection.

This story of the Zebu bears out the earlier experience with this type of animal at Ilorin. Including those mentioned above, there have been at one time or another since 1932, 40 Zebu animals on the Central Stock Farm and out of this number only the three mentioned above survive at the present time. It would therefore seem that the Zebu is definitely not an economic success for our purpose, as he does not generally possess a natural tolerance to the protozoal conditions of this area.

Management of Herds on Stock Farm.

For purposes of this investigation, cows of the Gold Coast Shorthorn, the Fouta Longhorn, and the Gambia Longhorn are being bred to bulls of their own type, and there will be no crossing at present. The females of the small shorthorn and Sanga herds are being mated in turn with bulls of each of the three 'pure' breeds. In course of time this will give cross bred progeny from one cow by a bull from each breed. A study of the tolerance to trypanosome infection exhibited by these progeny should give some indication of the power each bull possesses to transmit that tolerance. As it is also desired to increase size as far as possible, heifer calves of all breeds are not being put to the bull till they reach the age of two and half years. Bull calves are being used for services only after they are two years of age and then only to a very limited extent. The bulls are not being worked till they are four years of age, as it has been found that young beasts worked earlier are liable to breakdowns to trypanosomiasis.

All young stock and work beasts on the Stock Farm are temperatured daily. As might be expected, temperature rises are more frequently recorded among the young animals and work beasts than among the adult females; consequently after three years' recording, routine daily temperatures of the latter are not now taken. In cases where a temperature of over 102°F. is recorded for any animal, a blood smear is taken, which is examined by a Veterinary Officer; a note is made in the animal's history sheet if trypanosomes are seen in the smear. Of the 28 calves born on the Stock Farm in 1938, 22 exhibited trypanosomes during the year; all but one recovered spontaneously; as tsetse has not been found on this farm, infection must have been caused by mechanical means.

Trypanosomes were recorded in blood smears from the work beasts. These animals graze off the farm and water where there are tsetse. The Sanga work beasts showing trypanosomiasis have had to be treated to effect a recovery, but the Gold Coast Shorthorn beasts and the young bulls sired by Gold Coast Shorthorn bulls from Sanga cows have so far recovered spontaneously from whatever infection they have had. This would seem to indicate that these Gold Coast sires are able to transmit some increase of tolerance to their progeny out of cross bred cows.

Beasts used on the farm are at work for five hours, divided into two periods, morning and evening. They graze during the middle of the day, *i.e.* from 11 a.m. to 4.30 p.m. In addition to grazing, the work animals are fed a ration of 3 lbs. to 6 lbs. concentrates per day according to the work performed, balanced as far as available foods allow to the requirements of a 600 lbs. beast. These foods consist mainly of cassava, sweet potatoes, maize, sorghum, groundnuts and various pulses. In addition to the work beasts, cows in milk, young calves and young bulls are also fed a concentrate ration in addition to grazing. All other animals subsist on grazing alone except during the dry season when grass is scanty.

Future Developments.

The scheme, which will take many years to develop, is at present only in its initial stages. We still have to prove what type of bovine has the highest tolerance to protozoal infections; where it will be possible for cattle to live and be of economic value. Hand in hand with the preliminary investigations on stock, systems of mixed farming have to be evolved, to cover a wide variety of conditions and cropping, which will be suitable ultimately for demonstration to husbandmen.

Although there is very little definite knowledge of the effect of farmyard manure on the annual or permanent crops of the Southern Provinces, experimental work in the Eastern areas shows that a great increase in the fertility of the soil may be expected by applications of farmyard manure to farm land. Thus, at Umuahia in a small scale trial the application of four tons of farmyard manure to a crop of yams increased the yield by 140 per cent., and a large scale trial indicated that there was considerable increase in the yields of both maize and yams by applications of both two and four tons of farmyard manure. The present indication is that a dressing of four tons of farmyard manure is economically better than two tons. Much work though has still to be done.

A very important part of the development work will be to demonstrate how to manage stock in a more enlightened manner. At present the husbandman's knowledge of this essential condition for animal welfare is extremely rudimentary, and it will take many years to prove its value to him and for him to adopt it; for the future agricultural development largely depends upon the health of the cattle in addition to their tolerance to protozoal disease, and in this connection much work will be necessary on problems of a purely veterinary nature.

Summary.

For the purpose of the introduction of systems of mixed farming in the Middle Belt and Southern Provinces of Nigeria, several types of West African cattle are being tested in order to select animals with the requisite tolerance to the protozoal infection in those areas.

As a means of testing out these types of bovine small Unit Farms have been established in a number of areas of varying environmental conditions and tsetse incidence. Cropping schemes for these farms are evolved in accordance with local requirements and in relation to the capabilities of the cattle for economic agricultural work in each area.

There are distinct agricultural possibilities with the West African Shorthorn imported from the Gold Coast and with the West African Longhorn imported from the Fouta N'Dama area of French Guinea.

The Zebu of the Northern Provinces has proved the least tolerant, and mortality rates with this type in an area of comparatively low tsetse density have been high.

The improvement of the native cattle of Southern Nigeria by the use of improved sires is to be undertaken and more modern methods of animal husbandry demonstrated.

The development of animal products for sale is envisaged in areas where at present meat is scarce and milk is not generally used for food.

Acknowledgments.

I have to acknowledge my grateful thanks to Mr. O. T. Faulkner, C.M.G., late Director of Agriculture, Nigeria, to Capt. J. R. Mackie, Director of Agriculture, Nigeria for much kind advice and assistance over a period of years, to Dr. G. Bryce, O.B.E., Assistant Director of Agriculture who read my draft notes for his very helpful criticisms, to Mr. F. E. Buckley, Agricultural Officer, Umuahia for letting me have information relating to the work at Umuahia and to the Director of Veterinary Services, Nigeria and his staff for their valuable assistance in this investigation.

LOSSES TO WORLD AGRICULTURE THROUGH ROOT DISEASE OF CROPS.*

By S. D. Garrett.

(*Rothamsted Experimental Station, Harpenden, Herts.*)

The majority of the root diseases of crop plants are caused by soil fungi, though a few are due to plant pathogenic bacteria. Losses due to root disease are more important and more widespread than those due to root damage by soil insects. There are few crop industries which have not suffered severe loss from root disease in the past; sometimes indeed growers have even been forced to turn to the production of another crop. Mention may be made of the Panama disease of bananas in Central America and Jamaica, of Texas root rot of cotton in the U.S.A., of the root diseases of rubber in Malaya and of tea in India, Ceylon, and Nyasaland, of black root rot of tobacco in North America, and of the cereal root rots which occur in one form and another wherever cereals are grown. Intensive production of crops under glass has also its own root disease problems.

Root diseases are not confined to cultivated plants, being found commonly enough on wild plants growing under entirely natural conditions. The devastating effect and rapid spread of a root disease in a crop is, however, entirely a product of our methods of crop cultivation. The natural vegetation of any area of the earth's surface consists of an *association* of plants, highly characteristic for the particular area; the composition of this association is determined by climatic, soil, and biological factors. Examples of natural associations of plants are forest, prairie, moorland, and saltmarsh. A number of the plants forming such an association may be susceptible to one or more root diseases, but since many of the root disease fungi can attack only a few closely related species of plants, a single outbreak of root disease frequently peters out for lack of contact with fresh host plants before it has got very far. Let us consider what happens, for instance, when the Malayan jungle is cleared for rubber planting or the Canadian prairie or Australian scrub broken up for wheat growing. Certain disease fungi present on the jungle roots can attack the young rubber seedlings; a fungus parasitizing the roots of Canadian or Australian grasses finds the wheat plant a congenial host. When, therefore, the new crop of rubber or wheat is planted, these root disease fungi are able to spread continuously along the root network underground without check by quarantine barriers of other plants naturally immune to their attack.

The root disease fungi as a group show all gradations in specialization to the parasitic existence. Such pathogenic fungi actually constitute only a small proportion of the total fungus population of the soil. Fungi, together with bacteria, actinomycetes, protozoa, and other members of the soil microfauna and microflora, play an essential part in the economy of the soil, by breaking down the organic remains of plants and animals into simpler forms, such as ammonium salts and nitrates, which can be absorbed once more by the green plant. Fungi are especially important in the early stages of decomposition of crop residues, *i.e.* roots and trash left behind in the soil after harvest. Certain fungi, however, have acquired the ability to attack and invade the tissues of living plants. The more primitive of these fungal parasites, such as *Botrytis* spp. or grey moulds, can generally only initiate an attack on wounded, weakened, or moribund, plant tissues; once started the vigorously growing mycelium of the fungus is then often able to invade normal and healthy

* Reprinted from *Chemistry and Industry* Vol. 58, No. 43, pp. 953-58, 1939.

plant tissue. Increasing specialization in parasitism is accompanied, however, by loss of useful attributes as well as by acquisition of new ones. Thus the primitive root parasites are generally characterized by ability to grow freely through the soil, to live saprophytically on dead plant remains, and to attack a great variety of different plants. Their parasitism is frequently limited either to young parts of plants which have not yet developed their natural protection, to old parts of plants which are losing it, or to plants weakened by poor growing conditions. With increasing specialization to individual host plants the root parasite acquires the ability to attack the most vigorously growing plants in their prime; the fungus loses its power of attacking a wide variety of host plants and becomes restricted to a relatively small group of closely related plants. With increasing specialization too, the fungus generally seems to lose something of its original vigour of growth and hence, at least in part, its power of living on dead plant remains; such dead tissues may still be quite suitable for its nutrition, but are more quickly colonized by the more vigorously growing saprophytic (or non-parasitic) fungi.

This specialization of the root-infecting fungi is of more than theoretical interest. It so happens that the most dangerous and economically important root-infecting fungi are almost without exception of the specialized type. Specialization has left weak places in their economy; increasing advantage of these weaknesses of specialization is now being taken by modern control methods. Whereas, for example, the primitive parasites can frequently grow freely through the soil, the more specialized parasites are restricted to spread along the roots of their host plants and can only pass from one plant to another by root contacts. Again, whereas a primitive parasite can seldom be in any serious danger of dying out from any area of soil, owing to its wide host range and power of living on dead plant remains, the highly specialized parasite is threatened with extinction in the absence of its particular host or hosts. It is difficult in this connexion to over-estimate our debt to the pioneer work of Reinking and Manns (1933) in tropical America. As a result of their investigation into the status of *Fusarium oxysporum cubense*, causing the Panama disease of bananas, in the soil these investigators concluded that the tropical soil *Fusarium* fungi could be broadly divided into two classes, *soil inhabitants* and *soil invaders*. The soil inhabitants comprised the saprophytes and primitive parasites living mainly on dead plant remains, and were found in all the soil examined. The soil invaders, on the other hand, were the more highly specialized parasites which were found in the soil only in the proximity of their appropriate host plants; with the disappearance of the host, the fungus parasite dwindled and died out from the soil and was hence termed a soil invader. *Fusarium oxysporum cubense*, causing Panama disease, was found to be a soil invader.

So much then for the fundamentals of the biology of these root-infecting fungi. To what use is this knowledge put in the practical control of root disease? Whilst the precise mode of application of control measures varies from one crop to another, certain general principles of control are common to intensive or glasshouse cropping, annual or field cropping, and plantation cropping. Methods of root disease control may be classified as follows: (i) production of varieties of the crop plant resistant to the disease, (ii) plant sanitation, (iii) elimination of infectious material from the soil, (iv) checking underground activity and spread of the fungus, (v) increasing host resistance.

Production of disease-resistant varieties of the crop plant.

Certain varieties of our crop plants possess a natural resistance, which may even amount to immunity, to certain fungus diseases. By the processes of hybridization and selection the plant breeder often succeeds in blending this quality of disease resistance with other desirable attributes, such as heavy yielding capacity, high quality of product, earliness of maturity, &c. In some cases a wild plant may be used as a genetical source of the character for disease resistance, where no cultivated variety is available. Disease resistance of this type is rarely found except where the fungus parasite is specialized to a single species, or to a few closely related species, of host plant. A highly specialized parasite of this type is *Synchytrium endobioticum*, causing wart disease of potatoes; in areas infected by this organism in England only varieties of potato immune to the disease may be grown.

Plant sanitation.

The principles of plant sanitation, as applied to root disease control, are concerned with preventing infectious material from reaching the soil and from being transported from diseased to uncontaminated areas by various agencies. For example, the foot and root rot diseases of cereals affect not only the roots but also the basal part of the stem. The practice of burning the long stubble left after wheat harvest in Australia ensures the destruction at least of the infected plant material lying above ground which otherwise would be ploughed under the soil to infect later on the next crop of wheat. More important, however, is the prevention of spread of a disease to fresh areas by various agencies. Most common of these is infected planting material, whether true seed or bulbs, corms, tubers, cuttings, stools, or other vegetative propagating material. Control of spread of disease in this way, whether by rejection or by fungicidal treatment of infected material, is coming more and more within the power of the grower. Water is probably the most important agent of natural spread of soil-borne diseases, whereas wind is the chief mode of dissemination of fungus diseases affecting the aerial parts of plant. Infected soil may also be moved about the farm on cultivating implements

or on the feet of men and of working animals; the spores of some disease fungi can, like those of the common mushroom, pass unharmed through the gut of grazing animals and thus infect new fields either directly or indirectly by distribution in farmyard manure.

The importance of these agencies of root disease dispersal can be gauged by the fact that the failure to control the spread of Panama disease of bananas in Jamacia, following upon its appearance on the island early in 1912, was attributed by Smith (1932) firstly to the surreptitious and illegal use of infected planting stools by small holders and secondly to the spread of the organism by flood water and rivers.

Elimination of infectious material from the soil.

The more highly specialized and troublesome root disease fungi survive in the soil in infected plant residues, both roots and stumps; in addition many of these fungi possess special survival organs, known as resting spores and sclerotia which, like the seeds of some weeds, may survive in undisturbed soil for a period of years.

Under intensive glasshouse cultivation the annual turn-over is sufficiently large to justify economically the artificial sterilization of the soil by means of steam or electrical heat or by the use of chemical fungicides such as formaldehyde and carbon disulphide. These treatments not only kill out fungus an insect pests from the soil to the depth of effective treatment, but also have an undoubtedly beneficial effect upon the soil's fertility through the physical, chemical, and biological changes produced.

Root diseases of annual or field crops are most effectively kept within bounds by the old-established practice of crop rotation. The success of this method of root disease control depends upon specialization of parasitism in the root-infecting fungi. The system of crop rotation of greatest use for root disease control is one in which botanically related crops, such as different species of cereals, are separated in the rotation by at least one year of a botanically unrelated crop (*e.g.* a crucifer) or better still by two. The cereal parasites die out of the soil by starvation during the interval under cruciferous crops, and the crucifer parasites are likewise starved out during the interval under cereals. It is seldom possible to eradicate completely a soil-borne parasite in this way, but any form of rotation which periodically reduces the numbers of the pathogen to a sufficiently low level is satisfactory in practice. It is safe to say that root-infecting fungi have been the chief cause of failure in nearly all intensive cropping ventures, such as that of cotton in the Southern States of the U.S.A., and of wheat in North America, Australia and more recently in England. It is fortunate for us, however, that those unspecialized fungi of the soil inhabitant class which are not controllable by crop rotation are not on the whole of serious importance.

Eradication of root disease in tropical plantation crops such as rubber, tea, and bananas, is a more difficult problem inasmuch as the soil remains continuously under the same crop which cannot be removed from the soil to facilitate the operation of control measures against the root parasites. It has therefore been essential to eradicate diseased material from the soil either before the young plantation crop is started or in its early years. Such diseased material consists of the infected roots and stumps of jungle trees; the pathogenic organisms can spread from these to the roots of the young plantation crop. Formerly, the practice of "clean clearing" was generally adopted whereby the soil on the site of the future plantation was dug through to a depth of two to three feet, if not more, and all pieces of buried infected timber removed. This method of disease eradication was effective, but exceedingly costly even with supplies of cheap tropical labour. Recently Napper (1932-39), working at the Rubber Research Institute of Malaya, has invented an entirely new system of root disease eradication in young rubber plantations. The larger stumps are removed, after felling and clearing of the original jungle, but residual timber is allowed to remain. Every tree of the young rubber plantation is periodically inspected for root disease by a trained pest gang of native labourers at intervals of four to six months. Where infection is discovered it is traced back along the root of the young rubber tree to the piece of buried infected jungle timber which was its source. This is removed and burned and the infected root is appropriately treated generally with little loss to the young tree. It is difficult to overestimate the importance of this new method for root disease control in tropical plantation crops.

An ingenious method for control of *Armillaria mellea* root disease in the young tea plantations of Nyasaland has recently been put forward by Leach (1937). This root disease attacking the young tea bushes originates from the diseased stumps of certain species of jungle tree. Leach confirmed previous observation that the majority of the susceptible jungle stumps are not attacked by the *Armillaria* until after the felling of the tree. He discovered, however, that where the susceptible jungle trees had been ring-barked a year or more before felling the stumps became infected not by *Armillaria* but by non-parasitic or weakly parasitic fungi harmless in the young tea plantation. By taking the preliminary precaution of ring-barking the jungle tree some time before clearing, therefore, it appears to be possible to replace *Armillaria*, which would otherwise enter the roots of the stumps, by harmless fungi.

Checking underground activity and spread of the fungus.

The earliest direct method employed in the attempt to check radial spread of a root disease fungus was that of trenching designed to enclose and isolate the infected area from the surrounding healthy soil. Following the presumption, and later the establishment of the important fact that the more highly specialized root disease fungi spread along the roots of their host plants and not directly

through the soil, it was realized that the radial spread of a fungus from an infected plant might be stopped by the simple expedient of removing the surrounding plants in root contact with the infected individual. If the root disease was one which only killed the plant rather slowly the fungus might have spread beyond the first enclosing circle of plants before the originally-attacked individual appeared visibly diseased; in the case of such a slow acting root disease, therefore, it was deemed advisable to remove at least two complete circles of plants surrounding each obviously infected individual.

The most notable attempt to check the spread of a root disease in this way was made by the Department of Agriculture of Jamaica following upon the first appearance of the Panama disease of bananas on the Island early in 1912. Prompt rogueing of infected individuals and the plants surrounding them was enforced by quarantine legislation. As Cousins and Sutherland (1930) and Smith (1932) record, there is no doubt that the enforcement of this rogueing method greatly retarded the extension of the disease throughout the Island; where promptly and thoroughly carried out this control measure was completely effective. Unfortunately for the banana industry of Jamaica the rogueing method could prevent only the active spread of the fungus and not its passive introduction into new areas on infected banana stools used for planting or by carriage in flood water and rivers. At present the chief hope for the banana growers of Jamaica must lie in the production of disease resistant varieties.

Another practical development of the same principle has been introduced by Taubenhaus and Ezekiel (1931), following upon their establishment of the fact that *Phymatotrichum omnivorum*, causing the Texas root rot of cotton, spreads by growth along the roots and from one plant to another by root contact (Taubenhaus and Ezekiel, 1930). The root contact between adjacent areas of cotton is broken not by rogueing but by the interposition of a root barrier of plants immune to infection by *P. omnivorum* such as sorghum. Further developments may be expected in the interplanting of susceptible with resistant species as a means of checking the spread of root disease fungi.

In addition to these direct or mechanical methods much work is now in progress on the control of root disease by agricultural manipulation of soil conditions in such a way as to check subterranean activity or spread of a root-infecting fungus. Thus some root diseases are favoured by alkaline and others by acid soils, some by low and others by high soil temperature, some by rather wet and others by rather dry soils, a few by heavy textured soils but the majority by soils of light texture, and so on. The logical approach to the problem of root disease control by soil conditions is by way of a preliminary survey of the incidence of the disease on different soil types, followed by direct experimental confirmation of the conclusions from the field survey. It is possible to modify soil reaction considerably by application of lime or of sulphur, soil temperature by variation in date of planting in the case of field crops, soil moisture and aeration by drainage, cultivation, and the application of organic manures. Under glasshouse cultivation, of course, the soil can be made up according to any desired prescription —with water culture as a modern extreme development in one direction (Gericke, 1938).

A future development of control by soil conditions will probably take the form of matching the crop to the soil; instead of endeavouring to alter soil reaction or texture by agricultural methods in order to obtain control of root disease it may be possible by better planning to restrict crop production to soils unfavourable to serious root disease of the particular crop concerned. For example, in view of the discovery by Reinking (1935) that Panama disease of bananas is of serious importance only on soils of medium to light texture, it would be as well to choose a heavy soil for the establishment of a new banana plantation on land infected, or likely to become infected by the disease organism.

Increasing disease resistance of the host plant.

Whilst it is true that some varieties of crop plants may be resistant whilst others are moderately or extremely susceptible to a particular root disease it is at the same time often possible to increase the degree of resistance of the more susceptible varieties by modifying the plant's environment. Manurial deficiencies and lack of balance especially affect the resistance of the plant to disease. Two root diseases caused by fungi which can be greatly reduced by appropriate manurial treatment of the crop are *Fusarium vasinfectum* wilt of cotton in the U.S.A. and browning root rot of cereals in Canada which are controlled by application of potash and of phosphate respectively.

Bibliography.

Cousins, H. H., and Sutherland, J. B.—Rep. Dep. Sci. Agric. Jamaica (1929), 1930, 15-19.

Gericke, W. F.—Crop production without soil. Nature, Lond., 1938, **141**, 536-40.

Leach, R.—Observations on the parasitism and control of *Armillaria mellea*. Proc. Roy. Soc., B., 1937, **121**, 561-73.

Napper, R. P. N.—Rep. Rubb. Res. Inst. Malaya (1931—38) 1932—39.

Reinking, O. A.—Soil and *Fusarium* diseases. Zbl. Bakt., Abt. 2, 1935, **91**, 243-55.

Reinking, O. A., and Manns M. M.—Parasitic and other *Fusaria* counted in tropical soils. Z. Parasitenk, 1933, **6**, 23-75.

Smith, F. E. V.—Panama disease of bananas in Jamaica. Microbiol. Bull. Dep. Agric. Jamaica, 1932, **1**.

Taubenhaus, J. J., and Ezekiel, W. N.—Recent studies on *Phymatotrichum* root rot. Amer. J. Bot., 1930, **17**, 554-71.

Taubenhaus, J. J., and Ezekiel, W. N.—Cotton root rot and its control. Bull. Tex. Agric. Exp. Sta., 1931, **423**.

NEW POLYPLOIDS IN COTTON BY THE USE OF COLCHICINE.

By S. C. Harland.

Institute of Cotton Genetics, Sociedad Nacional Agraria, Lima, Peru.

The use of colchicine to produce new polyploids now has an extensive literature, and it is evident that if the necessary experimental conditions are worked out in some detail, there are few plants which do not respond to treatment. The purpose of this note is to report numerous successes in artificial polyploidization in the genus *Gossypium*.

Methods.

Success has been achieved by the following different methods, using in all cases a concentration of 0.05-0.10 per cent. of colchicine in distilled water.

1.—Treatment of dry, sulphuric acid treated seeds, for 12 to 24 hours.

2.—Treatment of 3 to 6 day old seedlings: (*a*) tops of seedlings only; (*b*) roots of seedlings only, the time of treatment being 12 to 18 hours.

3.—Treatment of vigorously growing shoots on 2 to 3 year old plants. Here the shoots were immersed in a test-tube of solution for 12 hours, and afterwards washed with distilled water. All other shoots on the plants were eliminated.

4.—Treatment of the cut ends of 3 to 4-inch vigorous shoots by immersion in solution for 12 to 18 hours, and afterwards bottle grafting on to strong stocks.

Table I indicates the material tried, the success achieved, and contains notes on the characters of the polyploids.

The most important results from the economic standpoint may be discussed. In the first place a doubling of the chromosome number of the tetraploid cottons is shown to be possible, but this results also in a *doubling of the cell size*, and thus while the octoploid *hirsutum* has considerably longer lint than the control, the hairs are so thick and weak that it is doubtful whether any improvement lies in new octoploids. It is, on the other hand, probable that a chromosome number of n=52 is beyond the optimum.

The present New World tetraploids (Upland, Sea Island, Egyptian, Bourbon, &c.) are now known to be allotetraploids with one Asiatic n=13 chromosome component (ancestral to *arboreum-herbaceum*) and one New World n=13 chromosome component (ancestral to *aridum*,

Table I.

Material.	Method.	Success + or −	Character of polyploid plant.
G. arboreum L. ...	1	+	Larger leaves, hairier, male and female sterile.
G. Thurberi ...	1	+	Larger leaves, male and female sterile.
G. barbadense L.... (Sea Island)	1	+	Larger, coarser, hairier leaves, but completely sterile on both female and male sides.
G. hirsutum L. ... var. U 4	1	+	Larger, thicker, hairier leaves. Some flowers fully fertile, with larger pollen grains, larger bolls. Lint longer by 20 per cent., hair weight increased, tensile strength lowered, diameter of hairs increased. Seeds fuzzier and heavier by 30 per cent.
G. arboreum n=13 × *G. Thurberi* n=13 (F_1)	1	+	Larger, less laciniated, thicker leaves. Female fertile with New World n=26 pollen (*hirsutum, barbadense*); setting bolls with full complement of seeds. Male sterile.
G. barbadense L. n=26 × *G. Thurberi* n=13 (F_1)	1	+	Almost fully fertile on both female and male sides. Lint long and fine; almost white.
G. barbadense L. n=26 × *G. Armourianum* n=13 (F_1)	3 and 4	+	Fully fertile on both female and male sides. Lint long and fine; greenish.
G. barbadense L. n=26 × *G. aridum* n=13 (F_1)	3 and 4	+	Fully fertile on both female and male sides. Lint not seen.

Thurberi, Armourianum, Harknessii). By crossing *arboreum* with *Thurberi* and doubling the chromosome number, we have virtually resynthesized an amphidiploid genetically closely related to the modern tetraploids. The relationship is so close that hybridization of the new n=26 (*arboreum-Thurberi*) with a large number of *hirsutum* and *barbadense* types has been carried out. Since the *Thurberi* genom carries immunity to Pink Boll Worm, the economic importance of these new crosses cannot be over-emphasized.

Although, as has been stressed, the new octoploid *hirsutum* offers little commercial possibilities, the new hexaploids *barbadense-aridum, barbadense-Thurberi* and *barbadense-Armourianum* with n=39 chromosomes seem to be exceedingly important since the addition of a wild genom carrying resistance to drought and to a number of diseases and insects results in new fertile types of great vigour and in some cases high lint quality.

The three new types with n=39 chromosomes have been inter-crossed, and all combinations are now available for further testing.

REVIEWS.

SILVICULTURE OF TRINIDAD AND TOBAGO.

By R. C. Marshall, *Oxford University Press*, London 1939. pp. 248, plates 16. Price 21*s*.

This book contains an Introduction in which the physiography and vegetation of the Colony are briefly outlined, the information being condensed from an earlier work of Captain Marshall, "The Physiography and Vegetation of Trinidad and Tobago", published in 1934 as Oxford Forestry Memoir No. 17. The bulk of the book consists of notes on the botanical description, ecological distribution, silvicultural characteristics and utilisation of some 250 species of trees and palms. A great deal of useful information is given and the book will form an excellent basis for the acquisition of essential knowledge by future Forest Officers in Trinidad.

It is unfortunate that six years have elapsed between Captain Marshall's departure from Trinidad and the publication of his book. Time has not stood still in Trinidad and much additional information has been acquired by the Forest Department there since his departure. To some extent, therefore, the book is already out of date at the time of its publication. Much work has been done on the distribution of species and fuller information on this subject would have been of great interest. Progress has also been made in silvicultural methods, and an account of the evolution of a cheap and successful technique for the regeneration of local hardwoods at Arena Reserve from the early days of clear felling and artificial regeneration to the present methods of natural regeneration assisted by a small amount of planting under shelterwood would have been of interest to all tropical foresters. Captain Marshall rightly stresses the fact that "the capital with which a forester works is the soil". He might have issued a strong warning of the dangers of clear-felling natural forest on poor soils as part of the technique of regeneration. Repeated experience in Trinidad has conclusively proved that clear-felling results in severe degradation of the soil lasting for some years unless the growth of the planted crop is rapid enough to form a more or less closed canopy by the end of the second season. An extremely rapid get-away is, therefore, an essential factor for any species which is to be regenerated under the clear-felling system, and the only species which fulfils this requirement in Trinidad is Teak (*Tectona Grandis*). All the valuable native timber trees of Trinidad will stand a certain amount of shade and regeneration under a light shelterwood has proved more successful and considerably cheaper than regeneration after clear-felling. The shelterwood system has the further advantage that should the regeneration fail to survive for any reason, *e.g.* insect attack, the ground is not left bare of vegetation and subject to degradation and soil erosion.

The author deals exhaustively with the silviculture of Cedar (*Cedrela mexicana* Roem). This species has up to now proved an insoluble mystery and all attempts to establish successful plantations of Cedar, as opposed to individual trees, have ended in failure. Many possible causes of this failure have been investigated by the Forest Department with the help of the Imperial College of Tropical Agriculture, but the solution of the problem is no nearer. The fact, not stated by Captain Marshall, that even trees up to six or seven feet in girth growing naturally in the forest have on many occasions been found to die back suddenly from the crown and perish, without any signs of insect or fungal attack, leads one to wonder whether the present climate of Trinidad may be unsuitable for this deciduous species, which might be a relic from former days when Trinidad may have possessed a drier climate. Whatever the reason, the best advice to give anyone contemplating the establishment of Cedar plantations would be Mr. Punch's advice to those about to marry—don't!

Captain Marshall has given a number of species local names which are not known in Trinidad. Thus 'St. Anne's Laurier' for *Nectandra rectinerva* Meissn and 'Naked Boy Wild Guava' for *Myrcia leptoclada* DC., are not recognised by local woodmen. The invention of local names for the purpose of differentiating between very similar species is perfectly justifiable, but the fact that such names are inventions should be stated in the text.

The list of 16 palms given by Captain Marshall could have been extended to include those palms collected and identified since his departure. Some 24 species have now been recorded,

including the Trash Palm, *Scheelia osmantha* Bart. which has a wide range of habitat, from the western end of the Northern Range through Chickland, Pointe-a-Pierre, Morne L'Enfer to Cedros. The significance of palms as indicator species is now more fully realised and more detailed notes on their distribution would have been of value.

Several recent changes in botanical nomenclature are not mentioned in the book. Thus the four species of Zanthoxylum listed are now recognised as species of Fagara, while Galba formerly *Calophyllum antillanum* Britton is now *Calophyllum lucidum* Benth. Many of the names of the palms have also been altered.

It remains only to be added that the book is beautifully printed and well illustrated by photographs and drawings. It is to be hoped that when the time comes for Captain Marshall to revise this useful book, he will take full advantage of the mass of information acquired since 1934 which is in the records of the Trinidad Forest Department.

J. C. C.

* * *

RANSOMES' "ROYAL" RECORDS.

A Century and a Half in the Service of Agriculture, *Ransomes, Sims & Jefferies, Ltd.*, Ipswich, 1939. pp. 96.

Messrs. Ransomes, Sims & Jefferies, Ltd., manufacturers of agricultural implements and machinery have to-day a business connection and sound reputation which are world wide. The firm was founded in 1789 by Mr. Robert Ransome at Norwich, and it has recently celebrated its 150th anniversary by issuing in book form a most interesting account tracing the history and development of the company from its foundation to the present day. Starting in a very small way as iron founders at Norwich, "Ransomes" has grown and expanded in the last century and a half until there is now hardly a branch of the agricultural engineering industry in which it has not some business interests. The Directors have maintained a progressive and practical policy from the beginning modifying the design, character and variety of their implements to meet changing demands from the agricultural community. The development of the firm is intimately linked with the revolution that has taken place in farming practice during the period, and it may truthfully be said that the company has had some considerable influence on the trend of events, on many occasions acting as pioneers by the introduction and manufacture of new or improved implements or machines of real value in the practical economy of the farm.

This history of the growth of the business of Ransomes, Sims & Jefferies has been carefully compiled and is attractively illustrated with period photographs or reproductions from old journals. The various milestones along the road of progress are clearly defined, and the volume provides a short but instructive historical sketch of the great improvements that have taken place in the type and range of agricultural implements in the last hundred years.

D. D. P.

MISCELLANEOUS NOTES.

Propagation of Cabbages by Cuttings.

According to an article in the *M. A. H. A. Magazine*, IX, No. III, pp. 89-90, a successful method of propagating especially desirable strains of cabbages has been evolved on Penang Hill, Malaya. The method is very simple as it has not even been found necessary to strike the cuttings in pots or boxes of specially prepared soil. They are merely planted out in the usual raised beds which are of a light, well drained soil.

When the cabbage is cut for use the old leaves are left on the stem which remains undisturbed in the ground. The bed is treated as for an ordinary crop, kept clean and watered when necessary. Shoots soon appear in the axils of these old leaves and in about one month's time these will be 4 to 5 inches long when they are at a suitable size to be cut away from the old plant. Quite a large piece of the old stem is cut away with the cuttings to form a large heel. It is from this heel that most of the roots arise. It is unnecessary to trim off any of the leaves from the cuttings which are planted out in open beds, inserted 1½ to 2 inches deep and spaced 15 inches apart. They will root in about three weeks. During this period it is better to shade them from bright sunshine.

The crop will reach maturity in from three to four months from the time of taking the cuttings.

A slight variation of the above method is to make two deep cuts at right angles across the top of the old stem and extending downwards about 2 inches. This will divide the top of the stem into four pieces. Fill the spaces thus made with light soil, and by the time the shoots are big enough to be taken from the old plant they will have formed quite a few roots. The rooted pieces are severed from the old plant and lined out in the same way as the cuttings.

Crops have been raised on Penang Hill by these methods for some time and have proved very satisfactory.

* * *

Conuga Coffee.

According to an article in *Bergcultures*, XIII, 726-32 N. M. de Light recommends the use of suitable clones of Conuga as from data on yield he shows that Conuga has, on occasion, surpassed Robusta. Conuga is self-pollinating and also flowers throughout the year, thus reducing the risk of losses. It is also resistant to various diseases and pests. The writer believes a correlation exists between the development of root hairs and productivity.

A CONTRIBUTION TO RAW SUGAR CLARIFICATION.*

By J. G. Davies.
(*Department of Sugar Technology, Imperial College of Tropical Agriculture, Trinidad.*)

[*The following account is an abridged version of a paper on the research work on raw sugar clarification carried out by the Department of Sugar Technology read before the Sixth Congress of the International Society of Sugar Cane Technologists, Louisiana, by the author, who represented the College. The writer wishes to acknowledge the very important parts played in the work by the following students: R. D. E. Yearwood* (1935-36), *S. Duncan* (1935-36) *and A. Gomez* (1936-37). *Without their enthusiastic co-operation, the progress of this work would have been considerably retarded.*—Editor.]

Recent clarification research may be stated to have been carried out during two periods. In the earlier period of about a decade ago, the fundamental mechanism of the ordinary cold liming process was examined. The present-day period, due to the advent of low claribility (1) juices, is concerned almost wholly with those juices. The College's contributions have been concerned with this period only.

The development of a new process must of necessity be based on considerations of the theory of clarification. It is known that the isoelectric point of cane colloids is about pH 5.0. Muller (2) and Farnell (3) therefore suggest liming after heating in order to insure a more complete precipitation of hydrous silica and of albumen. Muller further suggests superheating the juice. Honig (4) describes a process in which the lime is added in two doses, one before heating and the other after, and adds that the final reaction is more easily adjusted if the secondary lime supply is maintained at 2° Bé. In the compound clarification process, the raw mill juices are treated according to their purities with beneficial results.

Of the newer cane varieties, the chief factory offender would appear to be POJ 2878. Nearly all raw sugar countries have recorded their complaints about the low claribility of its juice, with the notable exception of Java, its country of origin, and of British Guiana. In order to overcome this difficulty, McCleery (5) advocates liming to pH 11.0 and then adding phosphoric acid in such quantity to the cold limed juice that the required reaction is maintained after heating and settling. The desired result is therefore obtained by the action of a large precipitate of calcium phosphate, which Davies, Duncan and Yearwood (6) have shown to yield a volume of mud far in excess of normal amounts. Forero (7) is of the opinion that the low claribility of POJ juice is due to the immaturity of the stalks and therefore suggests leaving the cane cut in the field for ten days.

Honig, in a private communication, states that in Java they consider a raw juice to be of normal composition when the $SiO_2 : R_2O_3$ ratio lies between 2 and 4 and the $P_2O_5 : R_2O_3$ ratio between 0.3 and 0.7. When the $SiO_2 : R_2O_3$ ratio is lower than 2, ferric iron is reduced to ferrous by sulphuring in what is understood to be a preparatory treatment prior to actual clarification. The reason for this step is that they consider raw sugar clarification chiefly from the inorganic standpoint.

Another line of attack on general clarification problems has been the advent of new settler designs. Outstanding in this respect is the large number of the continuous type which have been patented, no less than 21 during the period 1920 to 1935. Since then the Fortier (8) has appeared one of the features of which is the low juice velocity, and the Seip (9), which utilizes the principle of sludge filtration. Warren (10) has fully discussed the effect of the design of the intermittent type on the rate of settling, and as a result many new installations incorporate his suggestion of "bottom feeding" to reduce the time taken for agitation to cease and thus the volume of settlings. Fleshman (11) mentions the use of a centre well for the same purpose.

Investigation.

The research carried out in these laboratories has followed two main lines: (*a*) an attempt to determine the difference in character between a low claribility juice and a high claribility juice; and (*b*) the perfection of a suitable factory process for dealing with low claribility juices.

(*a*) Juice Character.

It is self-evident that the behaviour of cane juice during clarification is determined chiefly by its composition. If the factor or factors responsible for low claribility can be determined, then the reason for them can be investigated if necessary.

(1) "*Claribility*" is a term coined (by the author) to describe the manner in which a juice responds to the ordinary factory clarification process. Its only virtue is that it allows "easily clarified juices" and "refractory juices" to be graded on the same scale.

(2) *I.S.J.*, 1921, p. 579.
(3) *I.S.J.*, 1923, p. 358; 1924, p. 333.
(4) *I.S.J.*, 1931, p. 446.
(5) *I.S.J.*, 1934, p. 166.
(6) *I.S.J.*, 1936, p. 298.
(7) *Proc. Ninth Conf. A.S.T. Cuba*, 1935, p. 57.
(8) U.S. Patent 2,022,661; *I.S.J.*, 1936, p. 279.
(9) *I.S.J.*, 1938, p. 272.
(10) *Sugar News*, 1928, 9, p. 658.
(11) *A.H.S.T.*, 1937, p. 56.

* Reprinted from *Int. Sugar Jr.*, Vol. XLI, No. 492, pp. 463-465, 1939.

Clarification is a process of non-sugar elimination, hence these constituents are the ones requiring critical examination. They may be classified as follows :—

Carbohydrates : hemicelluloses, pentosans and pectins ; Organic nitrogen compounds : proteins (albumen, peptones), amino acids and acid amides ; Organic acids (other than amino) : aconitic, oxalic, succinic, glycollic and malic ; Colouring matters : chlorophyll, anthocyans, saccharetin and tannins ; Waxes, fats and soaps ; Inorganic salts ; and Free and organic silica.

Of these, organic acids and colouring matters can probably be disregarded. The others have been or are being examined.

Throughout this work, the juice of POJ 2878 is used as a typical low claribility juice. Its composition has been compared with that of typically high claribility juices, such as BH 10(12), B 726, &c. Several opinions have been expressed stating that the low claribility of POJ 2878 juice is essentially due to the uneven ripening of this variety. This results in the factory having to deal with a mixture of juices derived from canes of all ages. Furthermore, the presence of POJ 2878 juice in the factory is usually indicated by excessive frothing, and it had previously been observed (1) that the degree of frothing may be correlated with the pentosan content. The first part of the investigation, therefore, dealt with the organic colloids.

(i) *Organic Colloids.*

In accordance with the above-noted observation and in order to introduce the maturity factor, this phase of the research was carried out during the period before harvesting, namely, from November to February. The determinations other than routine analyses were :—

(*a*) Degree Brix, by the Zeiss Sugar Refractometer (28°C.) ; (*b*) Dye value, by cataphoresis apparatus, using Night blue (2) ; (*c*) Pectins, by the method described by Farnell (3) ; (*d*) Ether extract (waxes, fats, &c.), by a modification of the Hawaiian method ; (*e*) Pentosans (furfural-yielding substances), by precipitation with acetic acid and distillation with HCl ; (*f*) Total organic nitrogen, by the Missouri method (4) ; (*g*) Non-protein nitrogen, by the method described by Thomas (5) ; and (*h*) Protein nitrogen (colloid nitrogen), by difference.

Examination of the Brix and per cent. sucrose curves (not reproduced here) show that in the particular series of samples the low claribility juice was more mature than the high claribility juice. As regards the changes taking place during maturity, the dye number of both juice types slowly decreases and pectin per cent. t.s. (total solids) follows the same general trend. Pentosan per cent. t.s. fluctuates over wide limits in both types, but the trends show no appreciable change during these stages of maturity. The same remarks may be applied to protein per cent. t.s.

Table I.

	Low Clari-bility POJ 2878	High Clari-bility BH 10(12)
Brix	16.35	15.60
Per cent. Sucrose ...	12.28	13.47
Gravity Purity	75.10	86.34
pH	5.06	5.27
Dye Number	619	689
Pentosan per cent. t.s. ...	0.1250	0.1472
Ether Extract per cent. t.s.	0.2884	0.4160
Total Nitrogen per cent. t.s.	0.2260	0.1830
Non-protein Nitrogen % t.s.	0.1140	0.0980
Protein Nitrogen % t.s. ...	0.1120	0.0850

The two sets of results are concordant in that there is no appreciable difference in the dye number, pentosan per cent. t.s. or protein nitrogen per cent. t.s. in the two types of juices, and are discordant as regards non-protein nitrogen per cent. t.s. and ether extract per cent. t.s. The general conclusion that there are no outstanding and consistent differences to account for the difference in claribility therefore seems permissible. This applies only so far as these particular constituents are concerned.

(ii) *Ash and Phosphates.*

As a matter of general interest at this period, the ash per cent. t.s. and grms. P_2O_5 per 100 ml. of juice were also estimated by standard methods. The results are shown in Table II.

Table II.

	Ash % t.s.			Grms. P_2O_5 per 100 ml.		
	Max.	Min.	Mean.	Max.	Min.	Mean.
Low Claribility— POJ 2878 ...	1.774	1.223	1.503	0.048	0.019	0.035
High Claribility— BH 10(12) ...	1.285	1.074	1.181	0.016	0.010	0.013

The low claribility juice appears to contain more ash per cent. t.s. than the high claribility juice, and furthermore the minimum of the former is very little lower than the maximum of the latter. The means of the factory juice analyses are 1.498 and 1.179 for ash per cent. t.s. and 0.032 and 0.015 for P_2O_5 per 100 ml. for low and high claribility juices respectively.

(1) *Tropical Agriculture*, 1933, 10, p. 248.
(2) *I.S.J.*, 1926, pp. 23, 97, 137.
(3) *I.S.J.*, 1924, p. 480.
(4) *Annals Missouri Bot. Gard.*, 1925, 12, p. 367.
(5) *Pl. Phsy.*, 1927, 2, p. 62.

The results are of the same order as those reported in Table II, and show that factory expressed juices are similar in this respect. Further, the phosphate figures confirm the previous experience of these laboratories that POJ 2878 juice is higher in this constituent than that of BH 10(12). The reverse result is reported in Brazil (1) and Cuba (2).

In a later part of the investigation the phosphate status of low and of high claribility juices was examined, and it was observed that there appears to be a characteristic phosphate content of clarified juice for each variety, even when the raw juice content fluctuated over fairly wide limits. Typical results giving the P_2O_5 per cent. t.s. are appended in Table III.

Table III.

B 726.		BH 10(12)		POJ 2878	
Raw.	Clarified.	Raw.	Clarified.	Raw.	Clarified.
0.088	0.029	0.091	0.029	0.184	0.055
0.062	0.027	0.106	0.024	0.170	0.054
0.055	0.022	0.078	0.026	0.089	0.061
	0.026		0.026		0.057

A possible interpretation of these results is that part of the estimated phosphate is not in a form suitable for taking part in the reactions which occur during clarification. It is similar, therefore, to "unavailable sucrose". This leads to the possibility of organo-phosphate compounds existing in the juice and helps to explain on fundamental grounds why POJ 2878 does not behave as would be expected from its comparatively high phosphate content.

It is to be especially noted that this variety shows a residual phosphate in clarified juice of 120 per cent. more than that in the two high claribility varieties. Phosphate added to the juice as phosphoric acid is available for clarification reactions but the whole of the natural content is not, however carefully the process is operated. It is therefore thought that a better basis for assessing the phosphate concentrations considered optimum for clarification should be in terms of "grms. P_2O_5 to be eliminated" and that the effect of variety must also be considered.

(iii) *Silica.*

The marked difference in ash per cent. t.s. between the low and the high claribility juices appeared to warrant further investigation. The first ash constituent to be examined was silica, since it is known that this exists in the juice partly as an organic colloidal complex. Muller (3) has recognized this differentiation. As far as is known, no actual measurements have been made of the organic and the inorganic silica fractions in cane juice.

In order that such measurements could be carried out, a colorimetric method for the estimation of inorganic silica was adapted for use and a description of it has been published (4). The method of colour development is such that the organic silica fraction is not affected. It can be determined by difference after estimating total silica by incineration. A series of total and of inorganic silica determinations were carried out on a total of 30 or so juice samples of varying claribility. Table IV presents the mean of these results.

The outstanding observation to be made from these results is that the organic silica per cent. t.s. varies in inverse ratio to the claribility, and as such is the first juice constituent so far measured which shows such a well defined correlation. In all five varieties except one, the organic silica forms the greater part of the total silica present. It, therefore, appears that organic silica is a contributing factor to claribility. During clarification, and maintaining the clarified juice at pH 7.2, it undergoes a change, forming inorganic silica compounds. Evidence of this reaction is obtained from the data given in Table V.

Table V.

Variety.	Raw Juice.	Clarified Juice.	Per cent. Increase.
POJ 2878	0.024	0.087	262.80
B 726 ...	0.035	0.070	100.00
BH 10(12) ...	0.031	0.065	109.70

Table IV.

Variety.	Claribility.	Total Silica % t.s.	Inorganic Silica % t.s.	Organic Silica % t.s.	Organic per cent. Total.
POJ 2878	Low ...	0.166	0.024	0.142	85.6
Uba	Low ...	0.168	0.040	0.128	76.2
B 726	Medium-High ...	0.141	0.035	0.106	75.2
BH 10(12)	High ...	0.087	0.031	0.056	64.5
Co 213...	High ...	0.050	0.030	0.020	40.0

(1) *I.S.J.*, 1935, p. 315.
(2) *I.S.J.*, 1935, p. 447.
(3) *I.S.J.*, 1921, p. 579.
(4) *I.S.J.*, 1938, p. 105.

Further evidence as to the significance of silica in clarification is required before its exact rôle can be formulated. So far, clarification has been thought of more as a mass reaction due to the addition to the juice of chemicals and heat. It now appears likely that any future developments may have to take the form of selectively attacking one particular juice constituent. The practical difficulties of this likelihood are fully recognized and a successful solution must incorporate simplicity and cheapness. If this is so, and our knowledge of the mechanism of clarification can be extended, then it will be time to carry the investigation into the field and invoke the co-operation of the agronomist and the geneticist.

(*b*) Suitable Commercial Process.

A full description of the evolved procedure known as the Fractional Liming and Double Heating process has already been published (1). The scientific reasons for its success in Puerto Rico, Jamaica, Antigua, Trinidad and Queensland are not clearly understood, but since the main point of difference is the heat application, it appears likely that it is bound up in some way with this factor. With the modern high velocity heater, the action is so rapid and the juice is submitted to the heat treatment for so short a period that no technical objection can be sustained on this ground. In any case it is to be observed that after delivery into the subsiders, in almost any clarification process the temperature is maintained at or above 200°F. for the next hour. Daily experience shows that no appreciable inversion takes place during that period.

The special merits of the process, apart from its ability to handle low claribility juices, are the ease of installation and the low cost of the additional equipment required. Furthermore, the results are brought about not by the addition to the juice of a greater quantity of chemicals but by what is apparently the more efficient use of heat. The low mud volume and decreased time of settling are more in favour of a reduction in required subsider capacity than of an increase, such as would be necessary if, say, more chemicals had been advocated.

(1) *I.S.J.*, 1936, p. 298.

FIELD EXPERIMENTS WITH SUGAR CANE.

In Sugar Bulletin No. 6 of the British Guiana Department of Agriculture, C. H. B. Williams and C. Cameron give the results of the sugar-cane experimental work for the year ended June 30, 1939. Fifty-two variety tests and 24 fertiliser tests are included.

The variety trials continue to emphasize the great value to the industry of the variety of P.O.J. 2878, which is gaining in popularity over Diamond 10. The former standard cane, Diamond 625, is no longer a factor. Meanwhile the search for new and better varieties goes on. The relative merits of the principal varieties that have come through the tests are shown in the table (all tests made on plant canes).

Variety.	Mean tons Sucrose per acre (Corrected).	Yield per cent. (POJ 2878 =100).
D. 552/33	5.96	119.68
D. 166/34	5.77	115.86
D. 51/33	5.39	108.23
D. 119/34	5.26	105.62
D. 63/33	5.19	104.22
D. 109/34	5.14	103.21
D. 112/34	5.05	101.41
P.O.J. 2878 ...	4.98	100.00
D. 221/33	4.74	95.18
Diamond 10 ...	4.73	94.98
D. 116/34	4.68	93.98
D. 20/33	4.66	93.57
D. 44/33	4.53	90.96
D. 113/34	4.51	90.56
D. 295/33	4.46	89.56
D. 250/33	4.42	88.75
D. 111/34	4.42	88.75
D. 16/33	4.41	88.55
D. 85/33	4.17	83.73
D. 83/33	4.14	83.13
D. 189/33	4.09	82.13
D. 110/34	4.08	81.93
D. 58/33	3.95	79.32
D. 100/29	3.87	77.71
D. 49/33	3.15	63.25

Particular attention is directed to the variety D. 116/34. This is a cross between P.O.J. 2878 × Sorghum, which has proved so outstanding in the multiplication nurseries that it has already been distributed to the estates where it is being rapidly extended. In some of the trials it has given at 14 months as much as 50.36 tons of cane, with 14.61 per cent. of sugar and a juice purity of 87.8. No data are given regarding its disease susceptibility.

Among canes of foreign origin it is noted that Co. 213 outyields P.O.J. 2878 in cane tonnage, but its juice is not as good. On the other hand, the yield of Co. 213 as ratoons falls off much less rapidly than that of P.O.J. 2878, so that in a long crop cycle (4 to 6 harvests) Co. 213 might prove the better cane.

In the fertilizer trials the adverse conditions include soil acidity and phosphate fixation. In the face of the prevailing soil acidity the use of sulphate of ammonia, a fertilizer which tends to increase soil acidity, has been general because of its cheapness. Promising results have been obtained from nitrochalk. This material costs more than sulphate of ammonia, but it is non-acidifying and is likely to obviate the necessity for the use of limestone, and the planters are advised to make commercial trials with it.—(*Facts about Sugar*, Vol. 34, No. 11, pp. 37-38, 1939.)

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Digestibility of Coconut Oil.

Recent work on the rate of digestion of fats (*Biochem. Jour.* 1938, 32, 462), seems to favour coconut oil in this respect. The rate of digestion of various fats by pancreatic lipase was measured, the fat being prepared in the form of 'reconstituted cream' so that the fat was in the form of minute globules and the conditions comparable with those of actual digestion in the organism. The results are of particular interest and some of the conclusions worth quoting *in extenso*:—

Coconut oil was digested more rapidly than any other fat including butter. Almond oil, cocoa butter, groundnut oil, bacon fat, beef fat, oleostearine, cod liver oil, cotton seed oil, lard, mutton fat, olive oil, premier jus, soya bean oil; hardened whale oil and hardened groundnut oil were digested at a much slower rater than butter and all at approximately the same rate.

It seems possible that if margarine contain this fat (coconut oil) it may be more rapidly digested than butter. Coconut oil 'may prove a more valuable food than has hitherto been supposed'.

* * *

Substitution of Lactic Acid for Citric Acid in the Analysis of Basic Slag.*

In the course of experiments with a slag having a total phosphate-content equivalent to 13.2 per cent. of P_2O_5, Sirot and Joret have shown that 10.8 to 10.9 per cent. can be dissolved out in 30 minutes by means of a 2 per cent. solution of citric acid or by solutions of equivalent molecular strengths of lactic acid or malic acid; 7.4 to 7.6 per cent. by acetic acid or tartaric acid; 3.2 per cent. by oxalic acid, all of equimolecular strengths (*cf. Analyst*, 1919, 44, 180). Since citric acid and lactic acid behaved similarly and since the former was then the cheaper, these results have hitherto attracted little interest. The present authors have now repeated the experiments with 1, 2 and 3 per cent. solutions of these two acids and have shown that the difference between the two sets of results falls within the permissible limits of experimental error (*i.e.* 0.3 per cent., as phosphoric acid). This applied whether the period of agitation during extraction was 60 minutes with the 1 per cent. solution or 30 to 120 minutes with the 2 per cent. solution. Comparisons made on four samples of basic meal and with 2 per cent. solutions of the acids showed that the average difference between the results obtained with the two acids was 0.20 and 0.28 per cent. for the Lorentz and Popp (iron citrate) methods, respectively.

* Article by A. Heiduschka and H. Wünsche, *Chem.-Ztg.*, 1939, 63, 317. Reprinted from *Analyst*, Vol. LXIV, No. 760, p. 534, 1939.

Magnetite as a Source of Iron for Citrus.

It has previously been demonstrated by Eaton, who used sand cultures, that finely-ground magnetite, incorporated with the sand, served as a good source of iron for citrus seedlings. These findings have now been confirmed by H. D. Chapman, of the University of California Citrus Experiment Station. In a series of sand culture experiments, in which the nutrient solution was automatically flooded every hour, citrus seedlings developed chlorosis, and failed to make any growth in the absence of magnetite, while in the presence of 0.1 per cent. of magnetite, normal growth took place. The reaction of the solution by this arrangement was maintained between pH 5.9 and 7.0, a range within which the solubility of magnetite is extremely low, as shown by certain independent experiments. In carbon dioxide water, however, having a reaction of pH 4.1, the solubility is very appreciably increased. It is therefore concluded that iron absorption from magnetite results from local intimate contacts made between the plant-roots and the iron oxide particles.

The presence of added calcium carbonate (2.5 per cent.) necessitated a larger proportion of magnetite to prevent the development of chlorosis, except when the nutrient was flooded less frequently. A marked lowering of the reaction (pH) of the nutrient solution was observed as a result of less frequent flushing, presumably owing to the accumulation of carbonic acid arising from root respiration. The reaction of the solution therefore seems to exert appreciable influence on the ability of the plant roots to develop enough sufficiently-acid contact zones for the solution of adequate amounts of iron. It cannot be claimed that the reaction alone causes the immobilisation of iron in the plant, because the chlorosis can be cured by an increased supply of magnetite without a change in reaction.

The results of these experiments seem to emphasize the view that, in soil, the "soil solution" may be distinguished as two parts—the local intimate contact zones between plant-roots and soil particles, and the solution external thereto. Differences in amount of potentially-available iron compounds may decide whether chlorosis will develop in a calcareous soil or not. Gradual coating of the iron-mineral particles by precipitated carbonates, as a result of irrigation, however, may render the iron entirely unavailable. —(H. D. Chapman, *Soil Science*, 48, pp. 309-314.)

The Editor requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.